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ABSTRACT

One formal operational schema, hypothetical-deductive reasoning, is seen as most important to effective decisionmaking in planning and carrying out classroom lessons. While it is clear that formal thought schema are widely used in teaching, it is also understood that these reasoning schema are themselves dependent upon the more fundamental cognitive processes. Prerequisite development includes, among other foundation processes, information processing skills which facilitate predecision actions through more efficient or increased sensitivity, receptivity, and use of internal and external stimuli. The problem investigated in this study was to determine the effects of intervention training in cue attendance on preservice teacher performance in observing details, asking questions, constructing alternative hypotheses, analysis of classroom teaching, and planning and teaching a classroom content unit. Included in the intervention instruction and in the dependent variables were detail attendance, information search questions, hypothesis generation, and designing strategies for hypothesis testing. Results of the study supported the hypothesis that teacher education courses focusing, at least partially, on prerequisite cognitive processes can increase teaching effectiveness. (JD)

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Cognitive Modification as Intervention for Increasing Basic Skills in Classroom Planning and Teaching

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Cognitive Modification as Intervention for Increasing Basic Skills in Classroom Planning and Teaching

Dennis W. Sunal

BACKGROUND

The numerous recent reports of projected teacher shortages, ratings of teacher ability, and change in teacher education have a common theme, the supply and demand for quality teachers. Political and policy solutions recognize the teacher and teacher effectiveness as playing pivotal roles in moving toward a solution. The National Commission for Excellence in Teacher Education (1985) stated as a major assumption that teaching is a complex human endeavor guided by knowledge that is both scientific and artistic.

Teachers continually make, carry out, and evaluate complex decisions about the curriculum, the students, and instruction. Jere Brophy in a review of research (1982) of a number of studies reported positive correlations between higher teacher ability and performance of specific teaching strategies with higher student achievement. The action of generating and considering alternatives in constructing a decision is a complex task and one of extreme importance in teaching. Instructional decisions are crucial to all aspects of effective teaching and are made frequently, one every two minutes (Clark and Peterson, 1986). These activities are closely related to one of the piagetian formal thought schema, hypothetical-deductive reasoning. This level of performance requires highly developed teacher abilities. A second research paradigm, information processing, characterizes decision making as the interaction between the decision maker and

the task environment. During the process of making decisions teachers gather and encode information (search for meaning), generate alternatives for possible courses of action, and select and act out a course of action. Sternberg (1985) describes novice behavior, characterizing preservice and induction year teachers, as involving 1) unsystematic exploration, 2) inadequacy in experiencing and defining a problem, 3) restricted inferential thinking, and 4) impaired strategies for hypothesis testing. It is no surprise that increasing teacher effectiveness should deal with increasing the cognitive ability level of the teachers involved.

Teacher education programs have generally assumed that prerequisites for teaching are met through required courses, classroom experiences, and inservice programs. Based upon research in the area of life-long development of cognitive functioning, the validity of this assumption among professional teachers should be questioned. Teachers differ in their ability to use formal operational schema. Continuing research indicates that formal operational thought is not common to all university students (McKinnon & Renner, 1971). Various studies have indicated that a majority of preservice and inservice K-8 teachers function wholly on a concrete level (Juraschek, 1974; Dilling, Wheatly, and Mitchell, 1976; and Chiapetta, 1976; Sunal and Sunal,1985). Depending on the study sample up to 2/3rds of preservice teachers and 1/2 of inservice teachers do not approach problems at the formal operational level. Over the past 8 years, the work of a number of researchers in preservice and inservice education has implicated general developmental progress (e.g., Oja and Sprinthall 1978, Glassberg and Oja 1981, Lyons 1984) and more

specific intellectual development (e.g., Nelson and Ankney 1977, Peterson, Marx and Clark 1978, Martin 1983, and Sunal and Sunal 1980 and 1985) with teaching performance of classroom teachers. As a means to facilitate teaching effectiveness, intervention training in formal operational schema would appear very long term in obtaining classroom transfer effects. Suggested training in formal thought schema has received with mixed results (McKinnon & Renner 1971, Renner & Lawson 1975, Padilla 1981, Wyatt 1983, McKenna 1983).

One formal operational schema, hypothetical- deductive reasoning, is seen as most important to effective decision making in planning and carrying out classroom lessons. The schema provides a foundation for a number of classroom teaching behaviors such as 1) postulating decisions based on relevant variables derived from professional education experiences, 2) processing information, making decisions and anticipating problems without experiencing the events first, and 3) using if then reasoning in postulating solutions verifiable in future classroom observations (Sunal and Sunal 1985). While it is clear that formal thought schema are widely used in teaching, it is also understood that these reasoning schema are themselves dependent on of more fundamental cognitive processes. Prerequisite development includes, among other foundation processes, information processing skills which facilitate predecision actions through more efficient or increased sensitivity, receptivity and use of internal and external stimuli. This investigation examined prerequisite cognitive skills within the developmental and information processing framework relating to cue acquisition, formulation and

selection of relevant variables and the consideration of all relevant information in making decisions.

Use of the idea of prerequisite process skills hypothesizes the existence of formal schema but due to deficiencies in prerequisite abilities to use them, lack of coordination between schema, or immature form of the schema for use in complex situations they appear only in certain situations or not at all. A deficiency in prerequisite processes would cause observable changes in behavior. A state of deficiency is observable in the sense that these processes or related formal thought schema do not appear spontaneously, regularly and predictably in the professional classroom behavior of the individual teacher. Under certain conditions, especially under strong motivation or recall of modeled behaviors, adequate functioning of formal schema may appear. Consistent and regular use of formal schema is not common in deficient individuals lacking in consistent supporting prerequisite processes due to the sustained extreme amount of effort which is needed to overcome missing processes. The use of formal operational schema becomes too difficult. Lower level concrete operational schema become more comfortable to use, appear somewhat effective in classroom situations, and become the basis for the common type of behavior exhibited by a large segment of teachers in classroom teaching (Sunal and Sunal 1985). To increase the regularity of the use of the formal schema, intervention instruction in prerequisite cognitive processes becomes necessary.

Individuals differ in their ability to use prerequisite cognitive processes, specifically relating to cue acquisition and interpretation, which are determinents of decision making behavior

(Sieber and Lanzetta, 1964; Karlins, 1967; Wright, 1979; Copeland, 1987; and Sunal,1988). Intervention instruction using cognitive modification techniques in a number of other studies have been shown to effect changes in prerequisite cognitive processes and measures of intelligence in adolescents and adults (Haywood and Burke, 1977; Martin, 1983; Shayer and Beasley, 1987). Savell, Twohig, and Rachford (1986) in an extensive review of research report that intervention involving a general program, the Feuerstein Instrumental Enrichment method, designed for improving problem solving strategies has been successful in increasing adolescent cognitive functioning.

Specific intervention instruction involving the cue acquisition and interpretation has shown significant effects in near-transfer measures. Subjects were reported to have developed an increased ability to observe and recall cues, describe and explain events, ask questions for relevant facts, and give more and higher quality hypotheses in settings similar to training situations (eg. Sieber and Tanzetta, 1966; Salomon and Sieber, 1970; Wright, 1978; Fouler and Wright, 1980; and Sunal, 1988). Copeland (1987) concluded that results of his study on prerequisite cognitive processes suggest further research in information processing and may offer an explanation for observed differences in teacher's classroom monitoring abilities. The effects on prerequisite processes did not decrease over a two year time period (Wright, 1981). Quality of hypotheses can be measured and generation of alternative hypotheses can be taught (Salomon and Sieber, 1970; Quinn, 1971; Quinn and George, 1975).

Use of intervention instruction involving prerequisite cognitive skills with teachers has been successful in improving

ability to use probing questions in classroom discussions, giving clear and concise directions, in solving formal operational level problems, involvement of students in decision making, and in analysis of lesson plans (Orme, 1977; Waksman et. al., 1978; Wright, 1979; Martin, 1983; Demchik and Sunal, 1987; and Sunal, 1988).

Prerequisite cognitive processes are needed for effective hypothetical - deductive reasoning and its integration with other formal schema. For such specific teaching activities as lesson planning, classroom teaching, and performance analysis where hypothetical-deductive reasoning is needed, deficiencies in prerequisite processes could involve performance in at least nine areas. They are

1. Unrecognized need for or perception of clear and discrete sensory data allowing for appropriate distinction of instructional or classroom objects, events or interactions. (Clear Data)

2. Unrecognized need for perception or reporting of all data in relevant instructional variables. All of the data may not be perceived causing unrealistic approximations and inadaquate descriptions to be made. (Sufficient Data)

3. Lack of need and ability to obtain a wide range of precise data using different kinds of instructional data sources to describe relevant variables (Data Sources).

4. No organized approach in obtaining instructional data or to determine those types relevant to the goal or problem at

hand. Frequently, planning responses are made incorporating only part of the data. (Exploratory organization)

5. Lack of need and ability effectively store or to retrieve all classroom and student observations from memory. (Retrieval)

6. Lack of sufficient questions to guide acquisition of instructional data source information. (Questions)

7. Lack of need or ability to use different types of investigative strategies appropriate in obtaining instructional data. (Types of Questions)

8. Lack of ability to select relevant cues in defining an instructional problem. Hypothesis testing which is based on this process would be impaired due to the lack of discrimination of cues to be tested. (Cue Discrimination)

9. Inability or lack of need to use hypothetical-deductive reasoning or methods of hypothesis testing. Trial and error planning and teaching behaviors occur along with an inability to make appropriate use of the experences. If instructional or classroom problem cues are perceived as being discontinuous or discordant, ineffective attempts are made to process the information further. Alternative hypotheses are not made to put the cues in context with other data. No mental or trial testing is seen as necessary to check the validity of hypotheses, if they are given, or the relationship of cues to each other. (Hypothesizing)

The purpose of this study was to determine if intervention instruction in specific prerequisite cognitive process items 1 to

5, basic to the hypothetical-deductive reasoning schema, effects novice teacher decisions related professional activities. The problem investigated was to determine the effects of intervention training in cue attendance on preservice teacher performance in observing details, asking questions, constructing alternative hypotheses, analysis of classroom teaching, and planning and teaching a classroom content unit. Included in the intervention instruction and in the dependent variables were detail attendance, information search questions, hypothesis generation and designing strategies for hypothesis testing.

The following research questions were examined on the effects of type of intervention instruction.

1. Does instruction effect a teacher's perception and reporting of the number and type of appropriate data (prerequisite cognitive process items 1, 2, 4, and 5) observed in analyzing a classroom teaching episode (short term, far-transfer, in O_5)?

2. Does instruction effect a teacher's perception and reporting of data related to appropriate description of variables in decision making events? The outcome will be shown in number, type and quality of questions asked and alternative hypotheses constructed (prerequisite process items 3, 6, 7, 8, and 9) in analyzing physical problem events and a classroom teaching episode (short term, near and far-transfer in O_3, O_4, O_5)?

3. Does instruction effect the quality of performance in planning and teaching a classroom content unit in areas

related to intervention instruction in prerequisite cognitive process items 1 to 9 (delayed, far-transfer in O_6)?

4. Does the ability of the teacher, cognitive functioning level, affect the results of the instruction in planning and teaching a classroom content unit in areas related to intervention instruction in prerequisite cognitive process items 1 to 9 (delayed, far-transfer in O_6)?

PROCEDURE

Research Design

An experimental pre-posttest research design was used to test the research questions. The sample was randomly chosen from the population of subjects and assigned to two treatment groups. Each group was given the same experiences except for the treatment variable. Pretesting included determination of cognitive functional level (O_1) and planning and teaching ability (O_2). See Table I for a description of the research design. Background and context variables of subjects' experience, treatment and classroom conditions were measured. Posttests included near-transfer and far-transfer effects during short term and delayed time periods in investigating physical problems (O_3 and O_4), analyzing classroom teaching (O_5), and planning and teaching content lessons (O_6).

[Insert Table I Here]

Sample

The population consisted of 64 senior year preservice education majors at a large eastern land grant university. The home backgrounds were diverse, from rural to urban. The participants majored in early and middle childhood education in

grades K-8. Content majors formed about one-half of the group, 24 to 40 hours in a single academic field. Others specialized in early childhood or elementary education with a broader program. The teacher education program is field oriented, beginning with class visits in the sophomore year and ending with teaching assignments in classrooms during the entire last year. Forty sample subjects were randomly selected from the population to participate in the study in the semester before student teaching. During this time subjects were registered in a full load, common block of courses; social studies, mathematics, reading, science and general methods; and spent 40% of their time performing tasks and teaching in school classrooms.

Treatment

Two treatment groups were formed. The control group received lesson plan and curriculum evaluation training sessions. They evaluated a set of lesson plans, a text and computer software materials. Analysis involved determination of the materials' potential usefulness, matching materials to an appropriate group of target students, and suggesting modification of the lesson plan and other materials for most effective learning. The subjects worked 2 1/2 hours on this task. Feedback on work was provided during and at the end of the session.

The experimental group received direct intervention instruction in prerequisite cognitive process items 1 to 5 in an individualized format. These involved information processing skills of clear data, sufficient data, data sources, exploratory organization, and retrieval. Treatment effects were measured in these five in addition to the remaining cognitive processes.

Research assistants were individually trained according to specific intervention instruction procedures established as reliable and valid in previous studies (Salomon and Sieber, 1970; Wright, 1977). The cue attendance instruction provided experience in exploratory data processing behaviors which have been related in research to the nine previously described prerequisite cognitive processes. The experimental group subjects during the intervention instruction were requested to describe a difficult criterion number level of relevant details potentially useful in resolving a complex problem shown to them. The filmed problem was one of Richard Suchman's (1966a) Inquiry Development Program filmloops published by Science Research Associates as described and used in previous research performed by Wright (1978). The film consisted of discrepant events centered on a physical problem and was selected because of its abstractness.

The instruction began with introductory remarks regarding the nature and purpose of the task. An example of the activity was performed by the session instructor using a second Suchman filmloop, "The Knife." Then subjects were asked to observe and remember as many cues as possible during the showing of the second 2 1/2 minute film, "The Balloon in the Jar." Cues were reported and recorded from subjects only at the end of each showing. This was done until the subjects exhausted the number of cues seen and remembered. Repeated showings added details of cues observed to the original list. The film was shown as many times as required for the subjects to obtain the necessary criterion number.

The subjects were instructed not to attempt to explain why events were happening in the film or to give a response which could not be observed directly in the film. Duplicate and

non-observable details reported were written down but not counted. Appropriate responses were reinforced.

Instruments

Pre-treatment measures consisted of planning a classroom lesson and determination of subjects' level of cognitive functioning. See table 2 for a listing of the instruments used during the study. The instrument "Planning of a Classroom Lesson" (PLAN) evaluated subjects lesson plans and teaching in their assigned classroom. The lesson was to be a experiential science lesson designed to teach basic science process skills (Kauchek and Eggan, 1980). The lesson type was studied, experienced and modeled during the methods courses taught on campus. Following teaching, the subjects turned in the lesson plan, student evaluation results, and student work sheets for evaluation using a modified form of the Microteaching Skills Rating System (MSRS) (Sunal, 1978 and 1985). The MSRS System had eight subparts with a total of 40 items. The subparts were determined through a factor analysis. See table 3. A narrative evaluation and a numerical score ranging from 1 to 5 and averaged for a total score was obtained which reflected quality of planning and teaching. Three field coordinators evaluated and rated both the lesson plan materials and the teaching of the lesson in classrooms. All lessons were jointly evaluated and rated by two coordinators. Inter-rater correlations averaged 0.88 for the group of preservice teachers.

[Insert Tables II and III Here]

The Lawson (1978) "Classroom Test of Formal Reasoning" (CTFR) pretest was given to groups of ten through live demonstration.

Subjects wrote responses to questions and a rationale for each answer as described by Lawson. The cognitive functioning level was determined from the score obtained on CTFR for each subject.

Two of the four post-treatment measures consisted of short term, near- transfer measures titled "Question Search" (QS) and "Hypothesis Search" (HS). The questions were designed to test prerequisite cognitive processes three, four, and six to nine. This posttesting, given two days after the treatment, involved viewing one additional Suchman Inquiry Development Program film for each measurement. The filmloops were titled "Pendulum" and "Sailboat." After viewing the subjects were asked to state as many questions and hypotheses as they could about what they have seen on the film. Following Robert Suchman's (1966b) questioning strategy the subjects were asked to state questions about the first filmloop which ask only for known facts, not inferences or conclusions. Using procedures developed by Quinn (1971) and Salomon (1968), subjects were also requested to give as many alternative hypotheses (explanations) as possible to explain what was seen in the film. A response example was given for each of the instruments, QS and HS. The subject was shown the filmloop as many times as needed to develop answers for the questions. All subject responses were individually recorded and encouraging feedback given. Only appropriate responses were counted. The treatment instructor administered these last two instruments to subjects individually.

The "Analysis of Teaching" (AT) posttest involved viewing a film of a classroom lesson one week after the treatment session. The teacher involved in the lesson demonstrated appropriate and inappropriate teaching behaviors common to those seen with novice

teachers. Inappropriate behaviors involved the areas of lesson sequence, discipline, and classroom management (Mertens, 1977). Study subjects were asked to view the film and at the end write as many relevant details they could that were potentially useful in understanding the events occuring in the film. The ten minute film was repeated upon request. All responses were recorded. Two additional questions were asked similar to the search queries of the QS and HS instruments. Completion of this AT posttest involved short term, far-transfer effects in all nine prerequisite cognitive process areas.

Each of the final two posttests were administered to determine treatment far-transfer effects in delayed test situations. The "Teaching a Classroom Lesson" (TEACH) posttest was given three weeks after the first treatment session. The TEACH instrument was designed to test all nine prerequisite cognitive skills through determination of treatment interactive effects on the professional area of classroom teaching. This posttest, using the MSRS observational rating system evaluated the planning and teaching of a three lesson science content unit in the subjects' assigned school classrooms. The lessons concerned consecutive lessons to be given on three separate days and was to be modeled after one of the three instructional approaches suggested by Kauchek and Eggan (1980). The instructional approaches were studied, experienced, and modeled in the science methods course. The lesson plan forms required statements on the goal, objectives, procedures, and student evaluation for each lesson. Subjects were observed and rated in classroom teaching of the lessons by the previous field coordinators. All lesson plans,

audiotapes of lessons, and pupil papers and student records were turned in for an overall evaluation and rating.

Analysis

The data from the instruments were coded following sequences described in previous research studies. Lawson (1978) and Sunal (1978, 1980a, and 1982) described reliable and valid procedures for interpreting student responses. Wright (1975) described procedures for counting details, questions, and hypotheses. Content differences in statements were added to the counting procedure. Quinn's Hypothesis Quality Scale was used to determine the quality of the hypotheses constructed (Quinn and George, 1975). These procedures provided data for examining the treatment effects on prerequisite cognitive processe items one, two, five, six, eight, and nine.

Categories of questions given by the subjects were also analyzed, as described by Suchman (1966b), to determine the diversity in the types of inquiry patterns and kinds of data sources used. This was done in order to determine changes which might have taken place in planned and systematic information processing involving the prerequisite cognitive processes, items three, four, six, and seven. Suchman defined inquiry patterns as seeking Verification, verify some aspect of an event; Hypothesizing, ascertain the consequence of a change; Correlation, aspect of event or object necessary for the given result to be obtained; and Synthesis, whether the idea about causation was valid. These four types of inquiry patterns can each use any of four kinds of data as information sources. The kinds of data involve, Events, Objects, Conditions, and Properties.

Multiple and univariate analyses of variance were used to assess the equivalency of groups. The level of significance accepted in all analyses was 0.05.

RESULTS

Pretreatment measures included assessment of background variables, pretesting of classroom lesson plan writing, and level of cognitive functioning. Although the control group had slightly higher ratings in most areas, no significant statistical differences were found, see table IV. Study participants had a mean GPA for all previous courses of 2.9, on a 4 point scale, gave moderately positive ratings to academic foundation courses taken, taught in assigned classrooms where their cooperating teacher spent about 30 minutes on average per day teaching science to average ability students. Before treatment experiences both groups had significant difficulty in planning lessons, with major and minor elements missing or inappropriate. Both groups performed on average at the transitional level between concrete and formal reasoning on the Classroom Test of Formal Reasoning. A rating of 5 has been determined as concrete, 6-11 as transitional and 12-15 as formal (Lawson, 1978).

[Insert Table IV Here]

Research Question 1: Number and amount of appropriate data (short term, far-transfer O_5.

Analysis of subject responses on filmed problem events of classroom teaching, the Analysis of Teaching (AT) instrument, following the treatment experience found significant differences between groups in cognitive process items 1,2,4, and 5. Intervention instruction subjects recalled and reported a greater

number of details (F=5.71 P=.02) and a greater number of details about teacher and student behaviors than control subjects, see table V. Reports about classroom or lesson objects and events were the same for both groups. The reports of the intervention instructed subjects demonstrated increased levels of cognitive processes including 1) clear data, 2) sufficient data, 4) exploratory organization and 5) retrival.

[Insert Table V Here]

Research Question 2: Number, Type and Quality of Questions and Hypothesis (short term, near, and far-transfer) 0_5.

Questions asked:

The number and types of questions guiding acquisition of data source information was different for the two groups, see table VI. Analysis of variance run on all questions found that the intervention instructed group asked more questions about problem events on film, on the QS measure (F= 4.68 P=.04) and on the teaching episode AT measure (F= 4.15 P=.05) then the control treatment group. Multiple analysis of variance run on all question types was also found to be significant for both the QS and AT measures. The part scores for Hypothesizing questions, on the QS and AT measures, and Synthesis questions, on the QS measure, were found to be higher for the intervention group using additional univariate analysis. Multiple analysis of variance found that a significantly greater diversity of data sources were accessed by the intervention group than the control group on both the measures. More questions were used involving the Conditions catagory by intervention subjects then by control subjects. Intervention instruction involving data acquisition was related to increased number and more diverse types of questions guiding

acquisition of a wider data source base in near and far-transfer situations.

[Insert Table VI Here]

Hypothesis Construction

Intervention instruction affected the teachers' perception and reporting of data related to appropriate description of variables for use in hypothesis generation, see table VII. Intervention instructed subjects reported similar number of hypotheses as the control subjects but the quality of their hypotheses was significantly higher. Results were similar on both the Hypothesis Search (HS) and AT measures.

The description and organization of data by the intervention instructed subjects demonstrated significantly higher levels of prerequisite cognitive process skills over control instructed subjects in 3) data sources, 6) questions, 7) types of questions, 8) cue discrimination and 9) hypothesizing.

[Insert Table VII Here]

Research Question 3: Quality of Performance in Planning and Teaching (delayed far transfer, O_6)

During the third and fourth weeks following treatment both groups planned and taught a series of sequential lessons on a sequenced set of concepts. The subjects' lesson plans student products, and classroom teaching were evaluated as part of the "Teaching a Classroom Lesson" (TEACH) post treatment measurement. Analysis of variance was used to determine overall differences between group performance as measured with the MSRS observational rating system and its subparts.

Significant gains were made from the pre to post testing periods, as measured with the MSRS, by both treatment groups. The

gains in lesson plan writing and teaching ratings over an 8 week period were 0.78 for the intervention treatment group (post rating 3.50. SE=0.10) and 0.40 for the control treatment group (post rating 3.15, SE=0.11). On the post test significant differences were found between the groups (F=6.18, P=.02, R2=28%), with intervention instructed subjects' ratings 0.38 point higher than control subjects (see table 8). Items concerning lesson plan writing (Planning) only were significantly higher for the intervention group (F=6.06. p=.03). Differences in classroom teaching (Teaching) items were not significant. Analysis of MSRS subparts found the intervention group significantly higher in 3 of 8 areas. The areas were 1) teaching for student understanding, 3) questioning strategies and 7) planned lesson implementation. These three subparts accounted for 60% of the difference in overall rating between the two groups.

[Insert Table VIII Here]

Research Question 4: Effects of Cognitive Functioning Level and Treatment on Performance in Planning and Teaching O_6

Differences in level of cognitive functioning were noted earlier and investigated to determine the differential effects this variable may have in the intervention treatment process and resultant performance. Differences in performance were noted during intervention instruction. The average time spent in recalling and describing details between requested showings of the instruction films was 10.2 and 10.3 minutes for concrete and transitional level subjects and 8.2 minutes for formal subjects. Higher formal level subjects perceived and recalled data 20% more quickly. Most of the difference for the formal students resulted

in much larger blocks of details reported after the first and second film showings.

Comparison of cognitive development level with results from the TEACH post-test found significant differences between the groups using multiple analysis of variance ($F=9.81, p=.01$). Formal subjects were found to have better lessons which were implemented more effectively overall than non-formal subjects. Significantly higher levels were found with total MSRS rating and in five subparts (see table 9). Formal subjects performed significantly higher on the MSRS subpart ratings in teaching for student understanding, questioning strategies, matched lesson components, lesson sequence, and planned lesson implementation. Most of the difference, 93%, between all of the subparts were found in these five areas. The difference in performance in each of the three developmental levels is shown on table X. The intervention treatment was equally effective for the formal and transitional levels in bringing them to similar levels of performance, significantly higher than the control treatment. The greatest gain was experienced by the transitional subjects. Concrete subjects did not show any difference in MSRS ratings due to the intervention treatment. Formal level control subjects performed significantly better than other control subjects.

[Insert Table IX and X Here]

The level of cognitive demand at which successful performance of teaching activities becomes appreciably less was investigated. These teaching activities were represented by subparts of the MSRS observation rating system. Significant differences between cognitive functioning levels were noted above in 5 teaching areas.

Only these 5 areas were considered. Three other teaching areas ratings were not significantly related to cognitive level.

The level of cognitive demand at which successful performance becomes appreciably less (minimum demand level required) was determined for each teaching activity as one standard deviation above the level at which 50% of the subjects performed the activity. The percent of non-formal (2A, 2B) and formal subjects (3A, 3B) meeting this demand level was determined and plotted, figure 1. Two areas, matched lesson components and lesson sequence show the sharpest slope, with fewer than 10% of non - formal and 60% or more of formal teachers meeting the criterion. The differences were even more severe, greater then 50%, when only concrete operational teachers were included in the non-formal group. None of the concrete students performed successfully at the criterion level. Three areas with less extreme slopes, where significant cognitive differences existed, were 1) teaching for student understanding, 3) questioning strategies, and 7) planned lesson implementation. The differences in percent of success between the non-formal and formal groups in these areas were less, between 20 and 35 percent.

[Insert Figure 1 Here]

DISCUSSION AND CONCLUSION

Intervention instruction in cue attendance, the experimental treatment, was effective in changing preservice teachers' performance in near and far-transfer problem situations. In near-transfer situations relating to problems showing physical events on film, intervention instructed teachers generated more questions and alternative hypotheses in trying to explain the

events seen. In a far-transfer problem situation related to a filmed teaching episode, intervention instructed teachers perceived and recalled more details and generated more questions and alternative hypotheses in attempting to explain events seen. Both situations demonstrated the positive effects of the intervention instruction in all of the 9 prerequisite cognitive process areas basic to the consistent use of the hypothetical - deductive reasoning schema.

In delayed, far-transfer situations intervention instructed teachers demonstrated higher quality overall performance in planning lessons and teaching them in classrooms. Specific areas of significant differences occurred in teaching for student understanding, questioning strategies and planned lesson implementation. Each of these areas involved use of hypothetical-deductive reasoning in writing lesson plans and in interactive decisions made during teaching to obtain quality ratings. These results indicated a moderate effect of increasing prerequisite cognitive process levels on classroom planning and teaching behaviors and a continued far-transfer effect in delayed post testing.

The near-transfer results were in agreement with previously reported research involving similar instruction in prerequisite processes (Sieber and Tanzetta, 1966; Saloman and Sieber, 1970; Pouler and Wright, 1980; Demchik and Sunal, 1987; and Sunal, 1988). The far-transfer results were supported through use of different instruction materials but involving similar prerequisite processes with teachers (Waksman et.al, 1979; Wright, 1979; and Martin, 1983). Orme (1977) found teachers use of probing types of

questions in classrooms improved with instruction and this was supported in the present study.

The effect of cognitive functioning level on the results of intervention instruction in planning and teaching may help explain the magnitude of the intervention impact. Ratings of higher quality in areas of teaching performance were related to teachers functioning at the formal cognitive thought level. Non-formal teachers performed significantly lower. These results were similar to those obtained by Sunal and Sunal (1985). In this study intervention instructed transitional and formal operational level teachers' classroom teaching performance were similar and significantly higher than both control treatment concrete and transitional teachers and the intervention treatment concrete teachers. The results implicate the obtained teaching performance level with development of hypothetical - deductive reasoning schema involved in the formal operational stage and ability to utilize prerequisite cognitive processes. The results were more complex when specific teaching areas were examined. Two teaching areas were poorly performed by non-formal teachers and yet successfully by more than one half of the formal teachers. These same two areas were not significantly affected by the intervention treatment (see figure 1). Being formal operational alone was sufficient to obtain the significantly higher performance level. The problem involved in these teaching areas was either too difficult even to produce a start in making appropriate decisions or the level of performance difference involved too great a cognitive leap for the non-formal group to obtain significant progress. Also, the problems posed in these areas may not be related to the cognitive processes investigated. In either case,

for the majority of teachers who would lack facility in using hypothetical-deductive reasoning schema, intervention instruction in underlying prerequisite cognitive processes produced little effect in the use of the schema in making decisions in problems with this level of complexity or abstractness.

Three teaching areas were successfully performed by a minority of the non-formal teachers and by a majority of formal teachers. These three areas were significantly affected by the level of cognitive functioning and by the intervention treatment (see figure 1). The level of cognitive demand requested was less severe than the two previous teaching areas, since a portion of the non-formal groups performed successfully at this level. The intervention treatment increased the level of prerequisite cognitive processes and, thus, facility in using hypothetical deductive reasoning in making decisions in these teaching areas.

The three remaining teaching areas of planned lesson for active learning, lesson clarity, and evaluation also had elevated formal teacher ratings over non-formal teachers. The differences were not significant and generally small. The areas were unaffected by cognitive functioning level or by the intervention treatment. It was possible that the problems posed by these teaching activities were unrelated to the prerequisite cognitive processes around which the intervention treatment was developed. An alternative explanation was that the control treatment may have been equally well designed in producing effective performance in the area. The fact that cognitve functioning level was not related indicated additional explanations. One may be that the set of MSRS observational rating items which did not appropriatly measure performance in the area. Another may be teaching skill

areas which did not require a higher level of cognitive functioning. Practice and basically concrete operations may be as effective as formal reasoning in making decisions and solving problems in these areas.

Both type of teaching activity requested, formal abstractiveness, and cognitive functioning level of the novice teacher need to be taken into account in determining teaching effectiveness as defined in this study. In the teacher education courses examined in this study, intervention instruction produced the greatest change in teachers rated as transitional subjects and with types of teaching activity where the cognitive demand difference was not too great. However, formal teachers also did benefit from the instruction. The instruction was not aimed at teaching hypothetical -deductive reasoning. Its purpose was to facilitate the consistant and efficient use of this mental schema by increasing the level of supporting prerequisite cognitive processes. This study supported the hypothesis that teacher education courses focusing at least partially on prerequisite cognitive processes can increase teaching effectiveness. Additional instruction in education methods and content, the control treatment, was less efficient than intervention instruction in increasing novice teachers' performance in making decisions in using the education methods and content.

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TABLE I

INTERVENTION INSTRUCTION RESEARCH DESIGN

Groups	Activity			
	Pretests	Treatment	Posttests	
			Near-transfer, short term	Far-transfer, short term / delayed
Experimental N=20	0_1, 0_2	X_{1-1}	0_3, 0_4	0_5, 0_6
Control N=20	0_1, 0_2	X_{1-2}	0_3, 0_4	0_5, 0_6

Total N=40

X_1 Intervention instruction (X_{1-1}) or analysis and modification of classroom lesson materials (X_{1-2})

0_1 Classroom Test of Formal Reasoning (CTFR)

0_2 Planning of a Classroom Lesson (PLAN)

0_3 Questionning Inquiry Patterns on a Filmed Problem (QS)

0_4 Hypothesis Generation on a Filmed Problem (HS)

0_5 Analysis of Teaching Performance on Film (AT)

0_6 Lesson Planning and Teaching Performance in Classrooms (TEACH)

TABLE II

PREREQUISITE COGNITIVE PROCESS MEASURES

Variables	Variable Measurement Instruments: Time — Pretest	Treatment	Immediate Posttest	Delayed Posttest
A. Prerequisite Cognitive Process Skill Variables				
1. Clear Data		X_1	0_5 (AT)	
2. Sufficient Data		X_1	0_5 (AT)	
3. Data Sources		X_1	0_3 (QS), 0_5 (AT)	
4. Exploratory Organization		X_1	0_3 (QS), 0_5 (AT)	
5. Retrieval		X_1	0_5 (AT)	
6. Questions			0_3 (QS), 0_5 (AT)	
7. Types of Questions			0_3 (QS), 0_5 (AT)	
8. Cue Discrimination			0_4 (HS), 0_5 (AT)	
9. Hypothesizing			0_4 (HS), 0_5 (AT)	
B. Cognitive Development Level	0_1 (CTF0)			
C. Teaching Variables				
1. Analysis of Classroom Teachers				0_6 (TEACH)
2. Lesson Planning	0_2 (PLAN)			
3. Teaching Performance				0_6 (TEACH)

TABLE III

ROTATED FACTOR LOADINGS OF ITEMS, BY PRINCIPAL FACTORS, FOR THE MICRO TEACHING SKILLS RATING SYSTEM

	Principal Factor	% of Variance Accounted for	Factor Loading on Each Item		MSRS Instrument Items Description
1.	Teaching for Student Understanding	37	0.78	02	Planning matches student throught level
			0.50	03	Instruction matches student thought level
			0.63	06	Free from inaccuracy and trivial content
			0.76	20	Instruction went beyond planned activity
			0.76	22	Provided for student feedback
			0.59	33	Student entry level identified and used
			0.48	39	Discipline decisons delayed for information
			0.54	40	Discipline rules are taught
2.	Questioning Strategies	10	0.82	13	Student questions encouraged
			0.76	14	Meaningful discussions, T-S, S-S
			0.62	15	Sequences of questions utilized
			0.52	16	Instruction involves student inquiry
			0.60	17	Instruction involves students
			0.78	19	Instruction generated student enthusiasm
3.	Matched Lesson Components	6	0.78	04	Objectives clear and related to evaluation
			0.60	08	All lessons components matched on plan
			0.82	12	Sufficient time given for question type
			0.64	18	Student activities match plan activities
			0.84	30	Evaluation type appropriate
			0.67	31	Records of student progress appropriate
4.	Lesson Sequence	5	0.72	01	Student thought level evident in plan
			0.49	05	Objectives relate to a variety of goal areas
			0.85	09	Lesson sequence related to models
			0.44	11	Type of question related to objective
			0.44	24	Students performed exploratory behaviors
			0.60	25	Students involved with peers and content
5.	Planned Lesson Implementation	5	0.58	33	Student entry level identified and used
			0.84	34	Preparation before lesson appropriate
			0.64	35	Physical organization of room appropriate
			0.68	37	Instructions for management planned for

TABLE III (CONTINUED)

6. Planned Lesson for Active Learning	4	0.63	10	Convergent questions stressed thinking over recall
		0.78	- 36	Sources outside of classroom used in planning
		0.48	-38	Creative use of instructional materials
7. Lesson Clairty	4	0.80	- 07	Instructional activity clearly stated in plan
		0.45	23	Provided for individual differences
		0.43	28	Students interpret results from activities
8. Evaluation	3	0.46	29	Students use a variety of thinking skills
		0.65	- 32	Variety of evaluation types used
	74			

TABLE IV
PRETREATMENT / PRETEST RESULTS FOR BACKGROUND, LESSON PLAN WRITING AND LEVEL OF COGNITIVE FUNCTIONING

	Intervention Instruction Group		Control Instruction Group	
	Mean	S.E.	Mean	S.E.
Grade Point Average for all previous courses	2.84	0.10	2.92	0.12
Student Rating of Quality of Physical Science Courses taken (5 maximum)	3.50	0.32	3.63	0.27
Student rating of quality of Biological Science Courses taken (5 maximum)	3.58	0.39	4.05	0.34
Average time spent by cooperating teacher on Classroom Science (hours/week)	2.50	0.31	2.75	0.30
Ability level of students in assigned classroom (above average (1) to below average (5)	2.90	0.32	2.95	0.33
Rating of lesson plan writing (PLAN) before treatment (maximum rating 5)	2.72	0.22	2.75	0.16
Cognitive functioning level given as total rating on Lawson Test of Formal Reasoning (CTFR)	8.32	0.73	8.82	1.02

*Analysis of variance significant at the $P \leq .05$ level

TABLE V

Research Question 1: SUMMARY DATA ON PERCEPTION AND REPORTING OF APPROPRIATE DATA DURING OBSERVATION OF A TEACHING EPISODE

Instrument	Group Treatment 1 Intervention Instruction		Treatment 2 Control Instruction	
	Mean	S.E.	Mean	S.E.
Analysis of Teaching (AT)				
Total details described	20.2*	1.72	13.3	1.52
Part Scores				
- teacher behavior	9.6*	1.20	4.5	0.93
- student behaviors	5.0*	0.67	3.3	0.77
- events and objects	5.6	1.06	5.5	1.20

* Analysis of variance significant at the $P \leq .05$ level

TABLE VI

Research Question 2: SUMMARY DATA ON THE PERCEPTION AND REPORTING OF DATA RELATED TO DESCRIPTION OF VARIABLES IN TWO PROBLEM SITUATIONS

Instrument	Group Treatment 1 Intervention Instruction N = 20	Treatment 2 Control Instruction N = 20
Question Search (QS)		
Total Questions asked	11.6*	9.2
A. Part scores - Question types		
1. Verification	4.8	4.6
2. Hypothesizing	2.4*	0.9
3. Correlation	0.4	0.8
4. Syntheis	4.0*	2.9
B. Part Scores - Data Sources		
1. Events	3.2	3.1
2. Objects	1.0	0.9
3. Conditions	6.6*	5.1
4. Properties	0.8	0.2
Analysis of Teaching (AT)		
Total questions asked	6.9*	5.1
A. Part Scores - Question Types		
1. Verification	3.0	3.4
2. Hypothesizing	1.2*	0.2
3. Correlation	0.9	0.2
4. Synthesis	1.8	1.3
B. Part Scores - Data Sources		
1. Events	1.1	1.4
2. Objects	2.3	2.5
3. Conditions	2.7*	1.1
4. Properties	0.8	0.1

* Analysis of variance significant at the $P \leq .05$ level

TABLE VII

Research Question 2: SUMMARY DATA ON HYPOTHESIS CONTRUCTION IN TWO PROBLEM SITUATIONS

Instrument	Group Treatment 1 Intervention Instruciton N = 20	 Treatment 2 Control Instruction N = 20
Hypothesis Search (HS)		
Total Hypotheses Generated	4.3	3.7
Hypothesis quality	3.8*	2.9
Analysis of Teaching (AT)		
Total hypotheses Generated	7.2	6.2
Hypothesis Quality	3.5*	2.1

* Analysis of variance significant at the $P \leq .05$ level.

TABLE VIII

RESEARCH QUESTION 3: SUMMARY DATA ON CLASSROOM TEACHING PERFORMANCE

Instrument	Group Treatment 1 Intervention Instruction	Treatment 2 Control Instruction
Teaching a Classroom Lesson (TEACH)		
Average MSRS Rating	3.50*	3.15
Parts		
a. Planning (15)	3.61*	3.09
b. Teaching (25)	3.43	3.18
Subparts		
1. Teaching for Student Understanding	3.69*	3.19
2. Questioning Strategies	3.74*	3.28
3. Matched Lesson Components	3.08	2.71
4. Lesson Sequence	3.02	2.82
5. Planned Lesson Implementation	3.82*	3.25
6. Planned Lesson for Active Learning	3.70	3.68
7. Lesson Clarity	3.67	3.35
8. Evaluation	3.47	3.53

*Analysis of variance significant at the $P \leq .05$ level

TABLE IX

RESEARCH QUESTION 4: SUMMARY DATA ON COGNITIVE FUNCTIONING LEVEL AND TEACHING PERFORMANCE

Instrument	Cognitive Function Level: Non-Formal (N=26)	Cognitive Function Level: Formal (N=14)
Teaching a Classroom Lesson (TEACH)		
Average MSRS Rating	3.12 (SE = .12)	3.66* (SE=.14)
Concrete (N=9)	2.89 (SE = .18)	
Transitional (N=17)	3.24 (SE = .12)	
MSRS Sub Parts		
1. Teaching for Student Understanding	3.22	3.85*
2. Questioning Strategies	3.35	3.81*
3. Matched Lesson Components	2.66	3.34*
4. Lesson Sequence	2.68	3.36*
5. Planned Lesson Implementation	3.32	3.94*
6. Planned Lesson for Active Learning	3.63	3.80
7. Lesson Clarity	3.44	3.64
8. Evaluation	3.46	3.57

* Analysis of variance significant at the $P \leq .05$ level

TABLE X

VARIATION IN TEACHING PERFORMANCE, MSRS RATING, WITH TREATMENT AND COGNITIVE LEVEL DIFFERENCES

Cognitive Functioning	Treatment	
	Control	Experimental
Concrete Operational (2A, 2B)	2.73	3.03
Transitional (2B+)	2.98	3.60
Formal Operational (3A, 3B)	3.56	3.77

* Post hoc analysis using Tukey test. Significant at $P \leq .05$ level.

Figure 1

LEVEL OF COGNITIVE DEMAND AT WHICH SUCCESSFUL PERFORMANCE OF VARIOUS TEACHER ACTIVITIES DECREASES APPRECIABLY

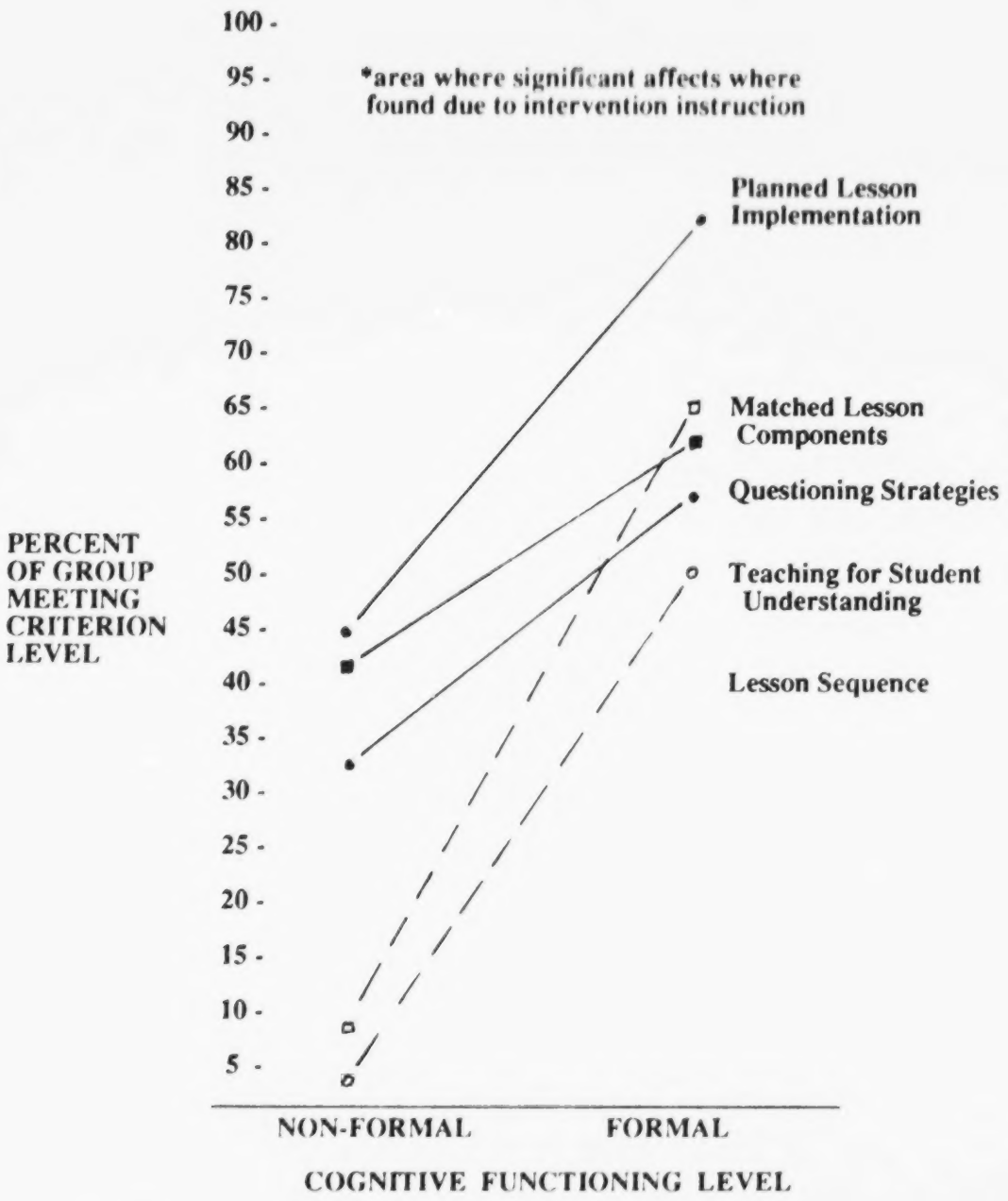

Figure 2

COGNITIVE FUNCTIONING LEVEL AND TEACHING PERFORMANCE

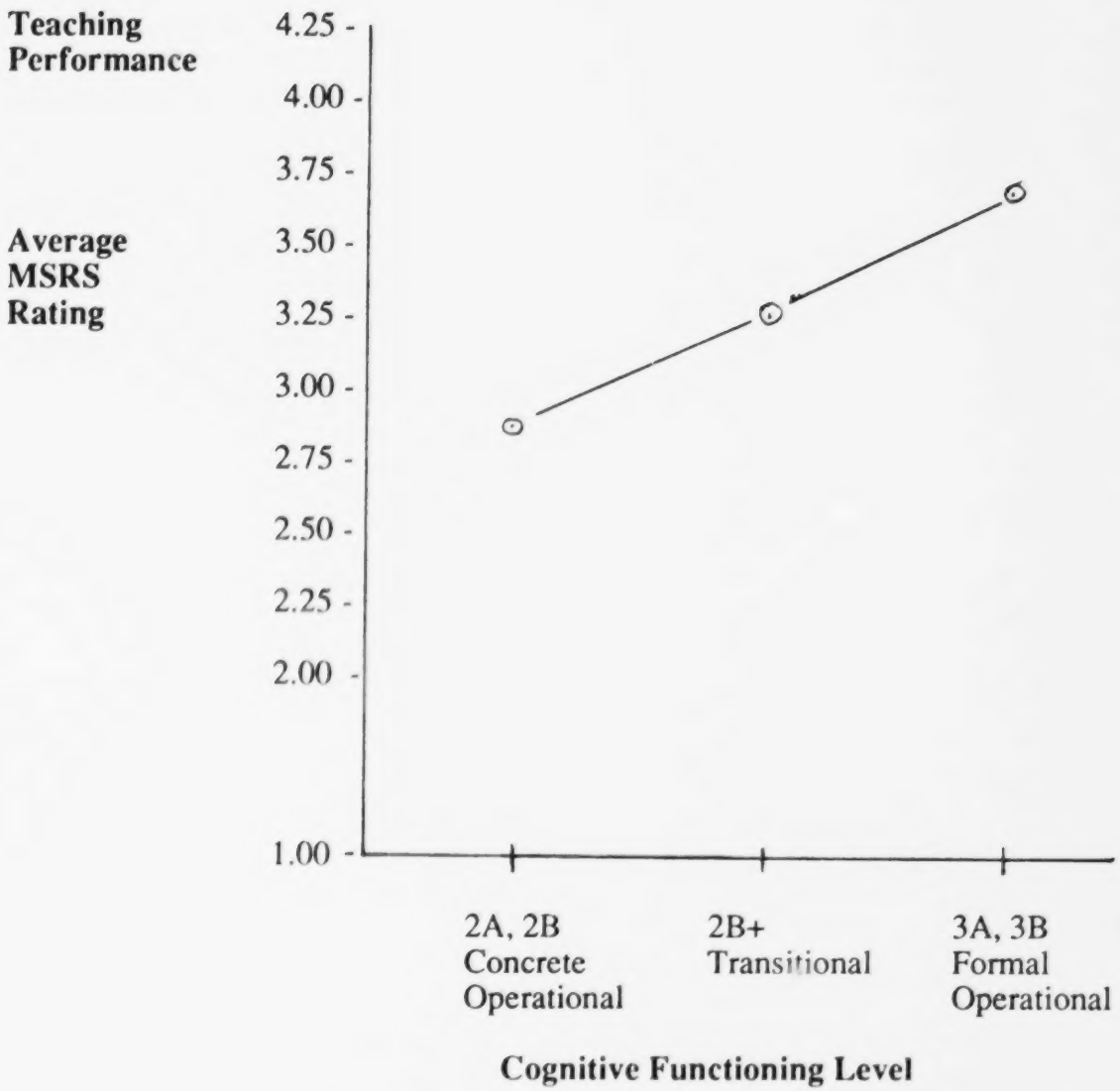

Figure 3

COGNITIVE FUNCTIONING LEVEL AND RESULTING TREATMENT DIFFERENCES